SEVEN
Philosophical Problems,
AND TWO
PROPOSITIONS
OF
GEOMETRY.

By Thomas Hobbes *of* Malmesbury.

With an Apology for Himself, and his WRITINGS.

Dedicated to the KING, in the year 1662.

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TO THE KING.

That which I do here most humbly present to Your Sacred Majesty, is the best Part of my Meditations upon the Natural Causes of Events, both of such as are commonly known, and of such as have been of late artificially exhibited by the Curious.

They are ranged under seven Heads. 1. Problems of Gravity. 2. Problems of Tides. 3. Problems of *Vacuum*. 4. Problems of Heat. 5. Problems of Hard and Soft. 6. Problems of Wind and Weather. 7. Problems of Motion Perpendicular, and Ob-

lique, &c. *To which I have added*, Two Propoſitions of Geometry; *One is*, The Duplication of the Cube, hitherto ſought in vain; *The other*, A Detection of the abſurd Uſe of Arithmetick, as it is now applied to Geometry.

The Doctrine of Natural Cauſes hath not infallible and evident Principles. For there is no Effect which the Power of God cannot produce by many ſeveral ways.

But ſeeing all Effects are produced by Motion, he that ſuppoſing ſome one or more Motions can derive from them the neceſſity of that Effect whoſe Cauſe is required, has done all that is to be expected from Natural Reaſon. And though he prove not that the thing was thus produced, yet he proves that thus it may be produced, when the Materials, and the power of Moving is in our hands; which is as uſeful as if the Cauſes themſelves were known. And notwithſtanding the abſence

of

of rigorous Demonſtration, this Contemplation of Nature (if not rendred obſcure by empty terms) is the moſt Noble Imployment of the Mind that can be, to ſuch as are at leiſure from their neceſſary Buſineſs.

This that I have done I know is an unworthy Preſent to be offered to a KING; *though conſidered (as God conſiders Offerings) together with the Mind and Fortune of the Offerer, I hope will not be to Your Majeſty unacceptable.*

But that which I chiefly conſider in it is, that my Writing ſhould be tryed by Your Majeſties Excellent Reaſon untainted with the Language that has been invented or made uſe of by Men when they were puzzled; and who is acquainted with all the Experiments of the time; and whoſe approbation (if I have the good Fortune to obtain it) will protect my reaſoning from the Contempt of my Adverſaries.

Epiſtle Dedicatory.

I will not break the cuſtom of joyning to my Offering a Prayer; And it is, That Your Majeſty will be pleaſed to pardon this following ſhort Apology for my *Leviathan. Not that I rely upon Apologies, but upon Your Majeſties moſt Gracious General Pardon.*

That which is in it of Theology, contrary to the general Current of Divines, is not put there as my Opinion, but propounded with ſubmiſſion to thoſe that have the Power Eccleſiaſtical.

I did never after, either in Writing or Diſcourſe, maintain it.

There is nothing in it againſt Epiſcopacy; *I cannot therefore imagine what reaſon any Epiſcopal-man can have to ſpeak of me (as I hear ſome of them do) as of an* Atheiſt, *or man of no Religion, unleſs it be for making the Authority of the Church wholly upon the Regal Power; which I hope Your Majeſty will think is neither Atheiſm nor Hereſie.*

But what had I to do to meddle with matters of that nature, ſeeing Religion is not Philoſophy, *but* Law?

It was written in a time when the pretence of Chriſt's Kingdom was made uſe of for the moſt horrid Actions that can be imagined; And it was in juſt Indignation of that, that I deſired to ſee the bottom of that Doctrine of the Kingdom of Chriſt, which divers Miniſters then Preached for a Pretence to their Rebellion; which may reaſonably extenuate, though not excuſe the writing of it.

There is therefore no ground for ſo great a Calamny in my writing. There is no ſign of it in my Life; and for my Religion, when I was at the point of Death at St. Germains, *the Biſhop of* Durham *can bear witneſs of it, if he be asked. Therefore, I moſt humbly beſeech Your Sacred Majeſty not to believe ſo ill of me upon reports, that proceed often (and may do ſo now) from the diſpleaſure which commonly ariſeth from difference in Opi-*

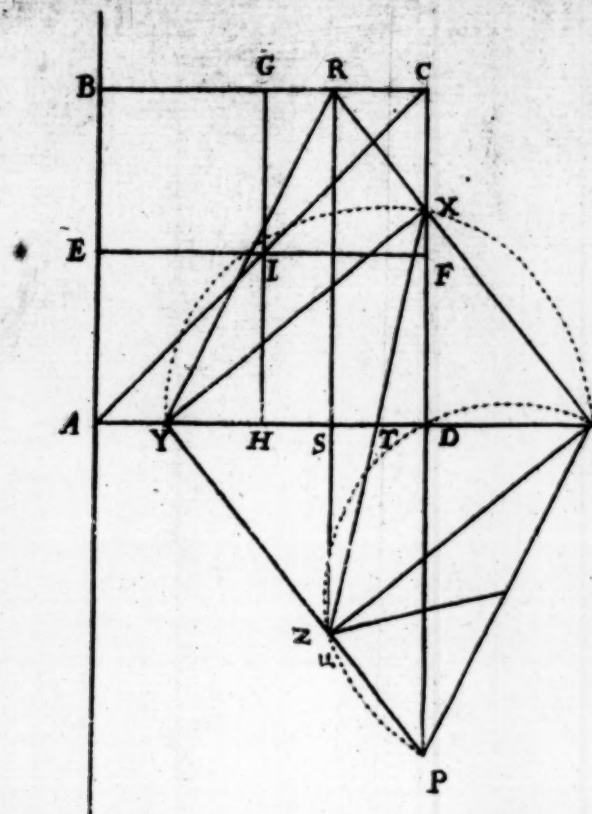
nion;

nion; nor to think the worſe of me, if ſnatching up all the Weapons to fight againſt Your Enemies, I lighted upon one that had a double edge.

Your Majeſties Poor and
moſt Loyal Subject,

THOMAS HOBBES.

PHILO-



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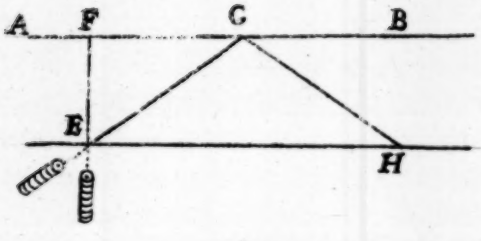

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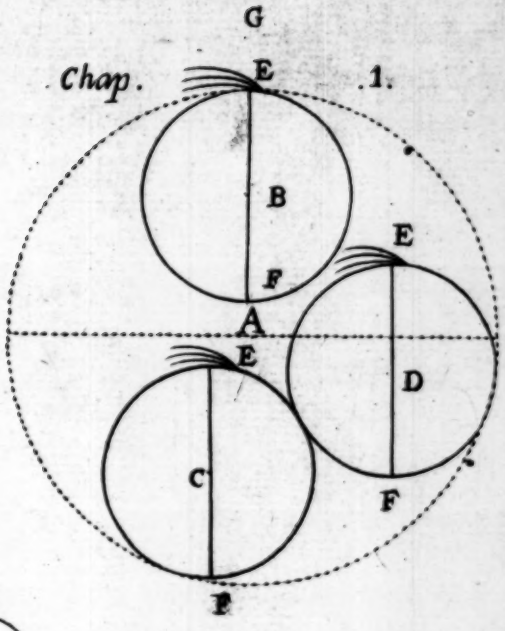

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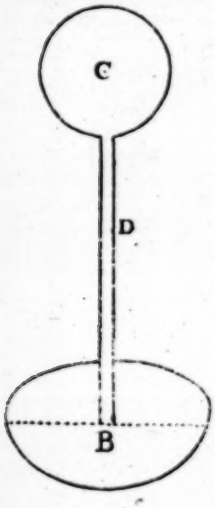

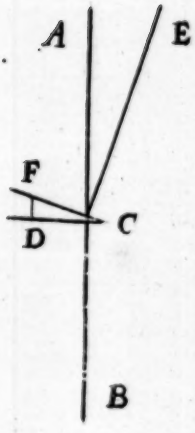

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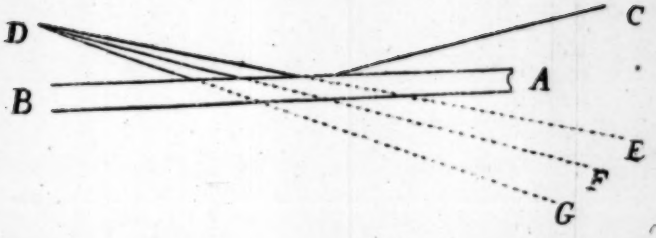

Chap: 5. Fig. 2.

PHILOSOPHICAL PROBLEMS:

CHAP. I.

Problems of Gravity.

A. *WHat may be the cauſe, think you, that ſtones, and other bodies, thrown upward, or carried up and left to their liberty, fall down again (for ought a man can ſee) of their own accord? I do not think (with the old Philoſophers) that they have any love to the Earth, or are ſullen, that they will neither go nor ſtay. And yet I cannot imagine what body there is above that ſhould drive them back.*

B. For my part, I believe the cauſe of their deſcending is not in any natural appetite of the bodies that deſcend, but rather that the Globe of the Earth hath ſome ſpecial motion, by the which it more eaſily caſteth off the Air, than it doth other bodies. And then this deſcent of thoſe we

call heavy bodies, muſt of neceſſity follow; unleſs there be ſome empty ſpaces in the world to receive them. For when the Air is thrown off from the Earth, ſomewhat muſt come into the place of it, (in caſe the world be full) and it muſt be thoſe things which are hardlieſt caſt off, that is thoſe things which we ſay are heavy.

A. *But ſuppoſe there be no place empty (for I will defer the Queſtion till anon) how can the Earth caſt off either the Air, or any thing elſe?*

B. I ſhall ſhew you how, and that by a familiar Example. If you lay both your hands upon a Baſen with water in it, how little ſoever, and move it circularly, and continue that motion for a while, and you ſhall ſee the water riſe upon the ſides, and fly over; by which you may be aſſured that there is a kind of circulating motion, which would caſt off ſuch bodies as are contiguous to the body ſo moved.

A. *I know very well there is; and it is the ſame motion which Country people uſe to purge their Corn; For the Chaff and Straws, by caſting the Grain to the ſide of the Seive, will come towards the middle. But I would ſee the Figure.*

B. Here it is. There is a Circle pricked out, whoſe Center is A, and three leſs Circles, whoſe Centers are B, C, D; let every

every one of them repreſent the Earth, as it goeth from B to C, and from C to D, always touching the uttermoſt Circle, and throwing off the Air, as is marked at E and F. And if the world were not full, there would follow by this ſcattering of the Air, a great deal of ſpace left empty. But ſuppoſing the world full, there muſt be a perpetual ſhifting of the Air, one part into the place of another.

A. *But what makes a ſtone come down, ſuppoſe from* G?

B. If the Air be thrown up beyond G, it will follow, that at the laſt, if the motion be continued, all the Air will be above G, that is, above the ſtone; which cannot be, till the ſtone be at the Earth.

A. *But why comes it down ſtill with encreaſing ſwiftneſs?*

B. Becauſe as it deſcends, and is already in motion, it receiveth a new impreſſion from the ſame cauſe, which is the Air, whereof as part mounteth, part alſo muſt deſcend, ſuppoſing as we have done the plenitude of the world. For, as you may obſerve by the Figure, the motion of the Earth, according to the Diameter of the uttermoſt Circle, is progreſſive; and ſo the whole motion is compounded of two motions, one circular, and the other progreſſive; and conſequently the

Air aſcends and circulates at once. And becauſe the ſtone deſcending receiveth a new preſſure in every point of its way, the motion thereof muſt needs be accelerated.

A. *'Tis true; For it will be accelerated equally in equal times; and the way it makes will encreaſe in a double proportion to the times, as hath heretofore been demonſtrated by* Galileo. *I ſee the ſolution now of an Experiment, which before did not a little puzzle me. You know that if two plummets hang by two ſtrings of equal length, and you remove them from the perpendicular equally, I mean in equal angles, and then let them go, they will make their turns and returns together, and in equal times; And though the arches they deſcribe grow continually leſs and leſs, yet the times they ſpend in the greater arches, will ſtill be equal to the time they ſpend in the leſſer.*

B. 'Tis true. Do you find any Experiment to the contrary?

A. *Yes; For if you remove one of the plummets from the perpendicular, ſo as (for example) to make an angle with the perpendicular of* 80 *degrees, and the other ſo as to make an angle of* 60 *degrees, they will not make their turns and returns in equal times.*

B. And what ſay you is the cauſe of this?

A. *Becauſe*

A. *Becauſe the arches are the ſpaces which theſe two motions deſcribe, they muſt be in double proportion to their own times; which cannot be, unleſs they be let go from equal altitudes, that is, from equal angles.*

B. 'Tis right; and the Experiment does not croſs, but confirm the equality of the times in all the arches they deſcribe, even from 90 degrees to the leaſt part of one degree.

A. *But is it not too bold, if not extravagant, an aſſertion, to ſay the Earth is moved as a man ſhakes a Baſen or a Seive? Does not the Earth move from Weſt to Eaſt every day once, upon his own Center, and in the Ecliptick Circle once a year? And now you give it another odd motion; How can all theſe conſiſt in one and the ſame body?*

B. Well enough. If you be a Shipboard under ſail, do not you go with the Ship? Cannot you alſo walk upon the Deck? Cannot every drop of bloud move at the ſame time in your veins? How many motions now do you aſſign to one and the ſame drop of bloud? Nor is it ſo extravagant a thing to attribute to the Earth this kind of motion; but that I believe if we certainly knew what motion it is that cauſeth the deſcent of bodies, we ſhould find it either the ſame, or more extravagant. But ſeeing it can be nothing above that

worketh this effect, it muſt be the Earth it ſelf that does it; and if the Earth, then you can imagine no other motion to do it withal, but this; And you will wonder more, when by the ſame motion I ſhall give you a probable account of the cauſes of very many other works of Nature.

A. *But what part of the Heaven do you ſuppoſe the Poles of your pricked Circle point to?*

B. I ſuppoſe them to be the ſame with the Poles of the Ecliptick. For, ſeeing the Axis of the Earth in this Nation, and in the annual motion keeps parallel to it ſelf, the Axis muſt in both motions be parallel as to ſenſe. For, the Circle which the Earth deſcribes, is not of viſible magnitude at the diſtance it is from the Sun.

A. *Though I underſtand well enough how the Earth may make a ſtone deſcend very ſwiftly under the Ecliptick, or not far from it, where it throws off the Air perpendicularly; yet about the Poles of the Circle methinks it ſhould caſt off the Air very weakly. I hope you will not ſay that bodies deſcend faſter in places remote from the Poles, than nearer to them.*

B. No; but I aſcribe it to the like motion in the Sun and Moon. For ſuch motions meeting, muſt needs caſt the ſtream of

of the Air towards the Poles; And then there will be the ſame neceſſity for the deſcent there, that there is in other places, though perhaps a little more ſlowly. For you may have obſerved that when it ſnows in the South Parts, the flakes of Snow are not ſo great as in the North; which is a probable ſign they fall in the South from a greater height, and conſequently diſperſe themſelves more, as water does that falls down from a high and ſteep Rock.

A. *'Tis not improbable.*

B. In natural cauſes all you are to expect is but probability; which is better yet then making Gravity the cauſe, when the cauſe of Gravity is that you deſire to know; and better then ſaying the Earth draws it, when the Queſtion is, how it draws?

A. *Why does the Earth caſt off Air more eaſily than it does Water, or any other heavy bodies?*

B. It is indeed the Earth that caſteth off that Air which is next unto it. But it is that Air which caſteth off the next Air; and ſo continually Air moveth Air; which it can more eaſily do then any other thing, becauſe like bodies are more ſuſceptible of one anothers motions; as you may ſee in two Lute-ſtrings equally ſtrained, what motion one

ſtring being ſtricken communicates to the Air, the ſame will the other receive from the Air; but ſtrained to a differing note, will be leſs, or not at all moved. For there is no body but Air that hath not ſome internal, though inviſible motion of its parts. And it is that internal motion which diſtinguiſheth all natural bodies one from another.

A. *What is the cauſe why certain Squibs, though their ſubſtance be either Wood or other heavy matter, made hollow and filled with Gunpowder, which is alſo heavy, do nevertheleſs when the Gunpowder is kindled, fly upwards?*

B. The ſame that keeps a man that ſwims from ſinking, though he be heavier then ſo much water; He keeps himſelf up, and goes forward by beating back the water with his Feet; and ſo does a Squib, by beating down the Air with the ſtream of the fired Gunpowder, that proceeding from its Tail makes it recoil.

A. *Why does any Braſs or Iron Veſſel, if it be hollow, flote upon the water, being ſo very heavy?*

B. Becauſe the Veſſel and the Air in it, taken as one body, is more eaſily caſt off than a body of water equal to it.

A. *How comes it to paſs, that a Fiſh (eſpecially ſuch a broad Fiſh as a Turbut or*

a

a Plaice, which are broad and thin) in the bottom of the Sea, perhaps a mile deep, is not preſs'd to death with the weight of water that lies upon the back of it?

B. Becauſe all heavy bodies deſcend towards one point, which is the Center of the Earth, and conſequently the whole Sea deſcending at once does arch it ſelf ſo, as that the upper parts cannot preſs the parts next below them.

A. *It is evident; Nor can there be poſſibly any weight, as ſome ſuppoſe there is, of a Cylinder of Air, or Water, or of any other liquid thing, while it remains in its own Element, or is ſuſtained and incloſed in a Veſſel, by which one part cannot preſs the other.*

CHAP.

CHAP. II.

Problems of Tides.

A. *WHat makes the Flux and Reflux of the Sea twice in a natural day?*

B. We muſt come again to our Baſen of water; wherein you have ſeen, whilſt it was moved, how the water mounteth up by the ſides, and withal goes circling round about. Now if you ſhould faſten to the inſide of the Baſen ſome bar from the bottom to the top, you would ſee the water, inſtead of going on, go back again from that bar, ebbing, and the water on the other ſide of the bar to do the ſame, but in counter-time; and conſequently to be higheſt where the contrary ſtreams meet together, and then return again, marking out four quarters of the Veſſel, two by their meeting, which are the high waters, and two by their retiring, which are the low waters.

A. *What bar is that you find in the Ocean, that ſtops the current of the water, like that you make in the Baſen?*

B. You know that the main Ocean lies Eaſt and Weſt, between *India* and the Coaſt

Coaſt of *America*; and again, on the other ſide, between *America* and *India*. If therefore the Earth have ſuch a motion as I have ſuppoſed, it muſt needs carry the current of the Sea Eaſt and Weſt; In which courſe, the bar that ſtoppeth it is the South part of *America*, which leaves no paſſage for the water, but the narrow Streight of *Magellan*. The Tide riſes therefore upon the Coaſt of *America*; And the riſing of the ſame in this part of the world proceedeth from the ſwelling chiefly of the water there; and partly alſo from the North Sea, which lieth alſo Eaſt and Weſt, and has a paſſage out of the South Sea by the Streight of *Anian*, between *America* and *Aſia*.

A. *Does not the* Mediterranean-*Sea lie alſo Eaſt and Weſt? why are there not the like Tides there?*

B. So there are, proportionable to their lengths, and quantity of water.

A. *At* Genoa, *at* Ancona *there are none at all, or not ſenſible.*

B. At *Venice* there are, and in the bottom of the Streights; and a current all along both the *Mediterranean*-Sea, and the Gulf of *Venice*; And it is the current that makes the Tides unſenſible at the ſides; but the check makes them viſible at the bottom.

A. *How*

A. *How comes it about that the Moon hath ſuch a ſtroke in the buſineſs, as ſo ſenſibly to encreaſe the Tides at Full and Change?*

B. The motion I have hitherto ſuppoſed but in the Earth, I ſuppoſe alſo in the Moon, and in all thoſe great Bodies that hang in the Air conſtantly, I mean the Stars, both fixed and errant. And for the Sun and Moon, I ſuppoſe the Poles of their motion to be the Poles of the *Æquinoctial*; which ſuppoſed, it will follow, (becauſe the Sun, the Earth and the Moon at every Full and Change are almoſt in one ſtreight line) that this motion of the Earth will be made ſwifter than in the Quarters. For this motion of the Sun and Moon being communicated to the Earth, that hath already the like motion, maketh the ſame greater; and much greater when they are all three in one ſtreight line, which is only at the Full and Change, whoſe Tides are therefore called Spring Tides.

A. *But what then is the cauſe that the Spring-Tides themſelves are twice a year, namely when the Sun is in the* Equinoctial, *greater than at any other times?*

B. At other times of the year, the Earth being out of the *Æquinoctial*, the motion thereof, by which the Tides are made, will be leſs augmented, by ſo much as a motion in the obliquity of 23 degrees

or

or thereabout (which is the diſtance between the *Æquinoctial* and Ecliptick Circles) is weaker then the motion which is without obliquity.

A. *All this is reaſonable enough, if it be poſſible that ſuch motions as you ſuppoſe in theſe bodies, be really there. But that is a thing I have ſome reaſon to doubt of; For, the throwing off of Air, conſequent to theſe motions, is the cauſe, you ſay, that other things come to the Earth; And therefore the like motions in the Sun, and Moon, and Stars, caſting off the Air, ſhould alſo cauſe all other things to come to every one of them. From whence it will follow, that the Sun, Moon, and Earth, and all other bodies but Air, ſhould preſently come together into one heap.*

B. That does not follow: For if two bodies caſt off the Air, the motion of that Air will be repreſs'd both ways, and diverted into a courſe towards the Poles on both ſides; and then the two bodies cannot poſſibly come together.

A. *'Tis true. And beſides, this driving off the Air on both ſides, North and South, makes the like motion of Air there alſo. And this may anſwer to the Queſtion, How a ſtone could fall to the Earth under the Poles of the Ecliptick, by the only caſting off of Air?*

B. It

B. It follows from hence, that there is a certain and determinate diſtance of one of theſe bodies (the Stars) from another, without any very ſenſible variation.

A. *All this is probable enough, if it be true that there is no* Vacuum, *no place empty in all the World. And ſuppoſing this motion of the Sun and Moon to be in the plain of the* Æquinoctial, *methinks that this ſhould be the cauſe of the Diurnal motion of the Earth; And becauſe this motion of the Earth is (you ſay) in the plain of the* Æquinoctial, *the ſame ſhould cauſe alſo a motion in the Moon on her own Center, anſwerable to the Diurnal motion of the Earth.*

B. Why not? what elſe can you think makes the Diurnal motion of the Earth, but the Sun? And for the Moon, if it did not turn upon its own Center, we ſhould ſee ſometimes one, ſometimes another face of the Moon, which we do not.

CHAP.

CHAP. III.

Problems of Vacuum.

WHat convincing Argument is there to prove, that in all the world there is no empty place?

B. Many; but I will name but one; and that is, the difficulty of ſeparating two bodies hard and flat laid one upon another; I ſay, the difficulty, not the impoſſibility. It is poſſible, without introducing *Vacuum*, to pull aſſunder any two bodies, how hard and flat ſoever they be, if the force uſed be greater than the reſiſtance of the hardneſs. And in caſe there be any greater difficulty to part them, (beſides what proceeds from their hardneſs) then there is to pull them further aſſunder when they are parted, that difficulty is Argument enough to prove there is no *Vacuum*.

A. *Theſe Aſſertions need demonſtration. And firſt, how does the difficulty of ſeparation argue the Plenitude of all the reſt of the world?*

B. If two flat poliſh'd Marbles lie one upon another, you ſee they are hardly ſeparated in all points at one and the ſame inſtant; and yet the weight of either of them

them it is enough to make them ſlide off one from the other. Is not the cauſe of this, that the Air ſucceeds the Marble that ſo ſlides, and fills up the place it leaves.

A. *Yes certainly. What then?*

B. But when you pull the whole Superficies aſſunder, not without great difficulty, what is the cauſe of that difficulty?

A. *I think as moſt men do, that the Air cannot fill up the ſpace between in an inſtant; For the parting is in an inſtant.*

B. Suppoſe there be *Vacuum* in that Air into which the Marble you pull off is to ſucceed, ſhall there be no *Vacuum* in the Air that was round about the two Marbles when they touched? Why cannot that *Vacuum* come into the place between? Air cannot ſucceed in an inſtant, becauſe a body; and conſequently cannot be moved through the leaſt ſpace in an inſtant. But emptineſs is not a body, nor is moved, but made by the act it ſelf of ſeparation. There is therefore (if you admit *Vacuum*) no neceſſity at all for the Air to fill the ſpace left, in an inſtant. And therefore, with what eaſe the Marble coming off preſſeth out the *Vacuum* of the Air behind it, with the ſame eaſe will the Marbles be pulled aſſunder. Seeing then, if there were

Vacuum,

Vacuum, there would be no difficulty of Separation; it follows, becauſe there is difficulty of ſeparation, that there is no *Vacuum*.

A. *Well now, ſuppoſing the world full, how do you prove it poſſible to pull thoſe Marbles aſſunder?*

B. Take a piece of ſoft wax; Do not you think the one half touches the other half as cloſe as the ſmootheſt Marbles? yet you can pull them aſſunder. But how? ſtill as you pull, the wax grows continually more and more ſlender; there being a perpetual parting or diſceſſion of the outermoſt part of the wax one from another; which the Air preſently fills, and ſo there is a continual leſſening of the wax, till it be no bigger than a hair, and at laſt ſeparation. If you can do the ſame to a Pillar of Marble, till the outſide give way, the effect will be the ſame, but much quicker, after it once begins to break in the Superficies; becauſe the force that can maſter the firſt reſiſtance of the hardneſs, will quickly diſpatch the reſt.

A. *It ſeems ſo by the brittleneſs of ſome hard bodies. But I ſhall afterward put ſome Queſtions to you, touching the nature of hardneſs. But now to return to our ſubject,*

What reaſon can you render (without ſuppoſing Vacuum) *of the effects produced in*

the Engine they use at Gresham Colledge?

B. That Engine produceth the same effects, that a strong wind would produce in a narrow room.

A. *How comes the wind in? You know the Engine is a hollow round pipe of brass; into which is thrust a Cylinder of wood covered with Leather, and fitted to the Cylinder so exactly as no Air can possibly pass between the leather and the brass?*

B. I know it; and that they may thrust it up, there is a hole left in the Cylinder to let the Air out before it; which they can stop when they please. There is also in the bottom of the Cylinder a passage into a hollow Globe of Glass; which passage they can also open and shut at pleasure. And at the top of that Globe there is a wide mouth to put in what they please to try conclusions on; and that also to be opened and shut as shall be needful. 'Tis of the nature of a Pop-gun which Children use, but great, costly, and more ingenious. They thrust forward, and pull back the wooden Cylinder (because it requires much strength) with an Iron screw. What is there in all this to prove the possibility of *Vacuum*?

A. *When this wooden Cylinder covered with leather, fit and close is thrust home to the bottom, and the holes in the hollow Cylinder*

linder of Braſs cloſe ſtopped, how can it be drawn back, as with the ſcrew they draw it, but that the ſpace it leaves muſt needs be empty. For it is impoſſible that any Air can paſs into the place to fill it?

B. Truly I think it cloſe enough to keep out Straw and Feathers, but not to keep out Air, nor yet matter. For ſuppoſe they were not ſo exactly cloſe but that there were round about a diſtance for a ſmall hair to lye between, Then will the pulling back of the Cylinder of wood force ſo much Air in, as in retiring it forces back, and that without any ſenſible difficulty. And the Air will ſo much more ſwiftly enter as the paſſage is left more narrow. Or if they touch, and the contract be in ſome points, and not in all, the Air will enter as before in caſe the force be augmented accordingly. Laſtly, though they touch exactly, if either the Leather yield, or the Braſs (which it may do to the force of a ſtrong ſcrew) the Air will again enter. Do you think it poſſible to make two ſuperficies ſo exquiſitly touch in all points as you ſuppoſe, or Leather ſo hard as not to yield to the force of a ſcrew? The Body of Leather will give paſſage both to Air and Water, as you will confeſs when you ride in Rainy and Windy weather. You

may therefore be aſſured that in drawing out their wooden-leather Cylinder they force in as much Air as will fill the place it leaves, and that with as much ſwiftneſs as is anſwerable to the ſtrength that drives it in. The effect therefore of their pumping is nothing elſe but a vehement Wind, a very vehement Wind coming in on all ſides of the Cylinder at once into the hollow of the Braſs Pipe, and into the hollow of the Glaſs Globe joyned to it.

A. *I ſee the reaſon already of one of their wonders, which is, that the Cylinder they pump with, if it be left to it ſelf, after it is pulled back will ſwiftly go up again. You will ſay the Air comes out again with the ſame violence by reflection; and I believe it?*

B. This is argument enough that the place was not empty. For what can fetch or drive up the Sucker, as they call it, if the place within were empty; for that there is any weight in the Air to do it, I have already demonſtrated to be impoſſible.

Beſides, you know, when they have ſucked out (as they think) all the Air from the Glaſs Globe, they can nevertheleſs both ſee through it what is done, and hear a ſound from within when there is any made. Which (if there were no other

other, but there are many other,) is argument enough that the place is ſtill full of Air.

A. *What ſay you to the ſwelling of a Bladder even to burſting, if it be a little blown when it is put into the Receiver, (for ſo they call the Globe of Glaſs?)*

B. The ſtream of Air that from every ſide meeting together, and turning in an infinite number of ſmall points, do pierce the Bladder in innumerable places with great violence at once, like ſo many inviſible ſmall wimbles; eſpecially if the Bladder be a little blown before it be put in, that it may make a little reſiſtance. And when the Air has once pierced it, it is eaſie to conceive, that it muſt afterward by the ſame violent motion be extended till it break. If before it break you let in freſh Air upon it, the violence of the motion will thereby be tempered, and the Bladder be leſs extended. For that alſo they have obſerved. Can you imagine how a Bladder ſhould be extended, and broken, by being too full of Emptineſs.

A. *How come living creatures to be killed in this Receiver, in ſo little a time as 3 or 4 minutes of an hour?*

B. If they ſuck into their lungs ſo violent a wind thus made, you muſt needs

think it will preſently ſtop the paſſage of their bloud; and that is death; though they may recover if taken out before they be too cold. And ſo likewiſe will it put out fire; but the Coals taken out whilſt they are hot, will revive again. 'Tis an ordinary thing in many Coal-pits, (whereof I have ſeen the experience,) that a wind proceeding from the ſides of the Pit every way, will extinguiſh any fire let down into it, and kill the workmen, unleſs they be quickly taken out.

A. *If you put a veſſel of water into the Receiver, and then ſuck out the Air, the water will boil. What ſay you to that?*

B. It is like enough it will dance in ſo great a buſtling of the Air; but I never heard it would be hot. Nor can I imagine how *Vacuum* ſhould make any thing dance. I hope you are by this time ſatisfied, that no experiment made with the Engine at *Greſham Colledge*, is ſufficient to prove that there is, or that there may be *Vacuum.*

A. *The World you know is finite, and conſequently, all that infinite ſpace without it, is empty. Why may not ſome of that* Vacuum *be brought in, and mingled with the Air here?*

B. I know nothing in matters without the World.

A. *What ſay you to* Torricellioes *Experiment in Quick-ſilver, which is this. There is a Baſon at* A *filled with Quick-ſilver; ſuppoſe to* B, *And* C D *a hollow glaſs pipe filled with the ſame. Which if you ſtop with your finger at* B, *and ſo ſet it upright, and then if you take away your finger, the Quick-ſilver will fall from* C *downwards, but not to the bottom. For it will ſtop by the way, ſuppoſe at* D. *Is it not therefore neceſſary that that ſpace between* C *and* D *be left empty? Or will you ſay the Quick-ſilver does not exactly touch the ſides of the glaſs pipe?*

B. I'le ſay neither. If a man thruſt down into a veſſel of Quick-ſilver a blown Bladder, will not that Bladder come up to the top?

A. *Yes certanly, or a Bladder of Iron, or of any thing elſe but Gold.*

B. You ſee then that Air can pierce Quick-ſilver.

A. *Yes, with ſo much force as the weight of Quick-ſilver comes to.*

B. When the Quick-ſilver is fallen to D, there is ſo much the more in the baſon. And that takes up the place which ſo much Air took up before. Whither can this Air go if all the World without that glaſs pipe B C were full? There muſt needs be the ſame or as much Air come

to that ſpace (which only is empty) between C and D. By what force? By the weight of the Quick-ſilver between D and B. Which Quick-ſilver weigheth now upward; or elſe it could never have raiſed that part higher, which was at firſt in the Baſon. So you ſee the weight of Quick-ſilver can preſs the Air through Quick-ſilver up into the pipe, till it come to an equality of force as in D. Where the weight of the Quick-ſilver is equal to the force which is required in Air to go through it.

A. *If a man ſuck a Vial that has nothing in it but Air, and preſently dip the mouth of it into water, the water will aſcend into the Vial. Is not that an argument that part of the Air had been ſucked out, and part of the room within the Vial left empty?*

B. No: If there were empty ſpace in the World, why ſhould not there be alſo ſome empty ſpace in the Vial before it was ſucked? And then why does not the water riſe to fill that, when a man ſucks the Vial he draws nothing out neither into his Belly nor into his Lungs, nor into his Mouth; only he ſets the Air within the glaſs into a circular motion, giving it at once an endeavour to go forth by the ſucking, and an endeavour to go back by

by not receiving it into his mouth. And ſo with a great deal of labour glues his lips to the neck of the Vial. Then taking it off, and dipping the neck of the Vial into the water before the circulation ceaſe, the Air with the endeavour it hath now gotten, pierces the water and goes out. And ſo much Air as goes out, ſo much matter comes up into the room of it.

CHAP. IIII.

Problems of Heat and Light.

A. *WHat is the cauſe of Heat?*

B. How know you, that any thing is Hot but your ſelf?

A. *Becauſe I perceive by ſenſe it Heats me.*

B. It is no good argument, The thing Heats me; therefore it is Hot. But what alteration do you find in your body at any time by being Hot?

A. *I find my skin more extended in Summer than in Winter; and am ſometimes fainter and weaker then ordinary, as if my Spirits were exhaled; and I ſweat.*

B. Then that is it you would know the cauſe of. I have told you before that by

by the motion I ſuppoſe both in the Sun, and in the Earth, the Air is diſſipated, and conſequently that there would be an infinite number of ſmall empty places but that the World being full, there comes from the next parts other Air into the ſpaces, they would elſe make empty. When therefore this motion of the Sun is excerciſed upon the Superficies of the Earth, if there do not come out of the Earth it ſelf ſome corporal ſubſtance to ſupply that teating of the Air, we muſt return again to the admiſſion of *Vacuum*. If there do, then you ſee how by this motion fluid bodies are made to exhale out of the Earth. The like happens to a mans body or hand, which when he perceives, he ſays he is Hot. And ſo of the Earth when it ſendeth forth Water and Earth together in Plants, we ſay it does it by Heat from the Sun.

A. *'Tis very probable, and no leſs probable, that the ſame action of the Sun, is that which from the Sea and moiſt places of the Earth, but eſpecially from the Sea fetcheth up the water into the Clouds. But there be many ways of Heating beſides the action of the Sun or of Fire. Two pieces of Wood will take Fire if in Torning they be preſt together.*

B. Here again you have a manifeſt la-

ceration

ceration of the Air by the reciprocal and contrary motions of the two pieces of wood, which neceſſarily cauſeth a coming forth of whatſoever is Aereal or fluid within them, and (the motion purſued) a diſſipation alſo of the other more ſolid parts into Aſhes.

A. *How comes it to paſs that a man is warmed even to ſweating almoſt with every extraordinary labour of his body?*

B. It is eaſie to underſtand, how by that labour all that is liquid in his body is toſſed up and down, and thereby part of it alſo caſt forth.

A. *There be ſome things that make a man Hot without ſweat or other evaporation, as Cauſtiques, Nettles and other things.*

B. No doubt. But they touch the part they ſo Heat, and cannot work that effect at any diſtance.

A. *How does Heat cauſe light, and that partially in ſome bodies more, in ſome leſs, though the Heat be equal?*

B. Heat does not cauſe Light at all. But in many Bodies, the ſame cauſe, that is to ſay, the ſame motion cauſeth both together; ſo that they are not to one another as cauſe and effect, but are concomitant Effects, ſometimes of one and the ſame motion.

A. *How?*

B. You know the rubbing or heard preſſing of the Eye, or a ſtroke upon it makes an apparition of Light without and before it, which way ſoever you look. This can proceed from nothing elſe but from the reſtitution of the Organ preſſed or ſtricken, unto its former ordinary ſituation of parts. Does not the Sun by his thruſting back the Air upon your eyes preſs them? Or does not thoſe bodies whereon the Sun ſhines (though by reflection) do the ſame, though not ſo ſtrongly? And do not the Organs of Sight, the Eye, the Heart, and Brains reſiſt that preſſure by an endeavour of reſtitution outwards? Why then ſhould there not be without and before the Eye, an apparition of Light in this caſe as well as in the other?

A. *I grant there muſt. But what is that which appears after the preſſing of the eye? For there is nothing without, that was not there before; or if there were, methinks another ſhould ſee it better, or as well as he; or if in the dark, methinks it ſhould enlighten the place.*

B. It is a fancy, ſuch as is the appearance of your face in a Looking-glaſs; ſuch as is a Dream; ſuch as is a Ghoſt; ſuch as is a ſpot before the Eye that hath ſtared upon the Son or Fire. For all theſe

are

are of the Regiment of Fancy, without any body concealed under them, or behind them, by which they are produced.

A. *And when you look towards the Sun or Moon, why is not that alſo which appears before your Eyes at that time a fancy?*

B. So it is. Though the Sun it ſelf be a real Body, yet that bright Circle of about a foot Diameter cannot be the Sun, unleſs there be two Suns, a greater and a leſſer. And becauſe you may ſee that which you call the Sun, both above you in the Skie, and before you in the Water, and two Suns (by diſtorting your Eye) in two places of the Skie, one of them muſt needs be Fancy. And if one, both. All ſenſe is Fancy though the cauſe be always in a real Body.

A. *I ſee by this that thoſe things which the Learned call the Accidents of Bodies, are indeed nothing elſe but diverſity of Fancy; and are inherent in the Sentient, and not in the Objects, except Motion and Quantity. And I perceive by your Doctrine you have been tampering with* Leviathan. *But how comes Wood with a certain degree of Heat to ſhine, and Iron alſo with a greater degree; but no Heat at all to be able to make water ſhine?*

B. That which ſhineth hath the ſame Motion

Motion in its parts that I have all this while ſuppoſed in the Sun and Earth. In which Motion there muſt needs be a competent degree of ſwiftneſs, to move the ſenſe, that is, to make it viſible. All Bodies that are not fluid will ſhine with Heat, if the Heat be very great. Iron will ſhine and Gold will ſhine; but water will not, becauſe the parts are carried away before they attain to that degree of ſwiftneſs; which is requiſite.

A. *There are many fluid Bodies, whoſe parts evaporate, and yet they make a flame, as Oyl, and Wine, and other ſtrong drinks:*

B. As for Oyl I never ſaw any inflamed by it ſelf, how much ſoever Heated, therefore I do not think they are the parts of the Oyl, but of the combuſtible body oyled that ſhine, but the parts of Wine and ſtrong Drinks have partly a ſtrong Motion of themſelves, and may be made to ſhine, but not with boiling, but by adding to them as they riſe the flame of ſome other body.

A. *How can it be known that the particles of Wine have ſuch a Motion as you ſuppoſe?*

B. Have you ever been ſo much diſtempered with drinking Wine, as to think the Windows and Table move?

A. *I confeſs (though you be not my Confeſſor)*

feſſor,) I have, but very ſeldom, and I remember the window ſeemed to go and come in a kind of circling Motion, ſuch as you have deſcribed. But what of that?

B. Nothing, but that it was the Wine that cauſed it; which having a good degree of that Motion before, did when it was Heated in the Veins, give that concuſſion (which you thought was in the window,) to the Veins themſelves, and (by the continuation of the parts of mans Body) to the Brain; and that was it which made the window ſeem to move.

A. *What is Flame? For I have often thought the Flame that comes out of a ſmall heap of Straw, to be more (before it hath done Flaming,) then a hundred times the Straw it ſelf.*

B. It was but your Fancy. If you take a ſtick in your hand by one end, the other end burning, and move it ſwiftly, the burning end, if the Motion be circular, ſhall ſeem a circle; if ſtreight, a ſtreight line of Fire, longer or ſhorter, according to the ſwiftneſs of the Motion, or to the ſpace it moves in. You know the cauſe of that.

A. *I think it is, becauſe the impreſſion of that viſible Object, which was made at the firſt inſtant of the Motion did laſt till it was ended. For then it will follow that it*

muſt

muſt be viſible all the way, the impreſſions in all points of the time being equal.

B. The cauſe can be no other: The ſmalleſt ſpark of Fire flying up ſeems a line drawn upward; and again by that ſwift circular Motion which we have ſuppoſed for the cauſe of Light, ſeems alſo broader then it is. And conſequently the Flame of every thing muſt needs ſeem much greater then it is.

A. *What are thoſe ſparks that flie out of the Fire?*

B. They are ſmall pieces of the wood or Coals, or other Fuel looſened and carried away with the Air that cometh up with them. And being extiguiſhed before their parts be quite diſſipated into others, are ſo much Soot, and black, and may be fired again.

A. *A Spark of Fire may be ſtricken out of a cold ſtone. It is not therefore Heat that makes this ſhining.*

B. No 'Tis the Motion that makes both the Heat and ſhining; and the ſtroke makes the Motion. For every of thoſe Sparks, is a little parcel of the ſtone, which ſwiftly moved, imprinteth the ſame Motion into the matter prepared, or fit to receive it.

A. *How comes the Light of the Sun to burn almoſt any combuſtible matter by refraction*

refraction through a convex glaſs, and by reflection from a concave?

B. The Air moved by the Sun preſſeth the convex glaſs in ſuch manner as the action continued through it, proceedeth not in the ſame ſtreight line by which it proceeded from the Sun, but tendeth more toward the center of the body it enters. Alſo when the action is continued through the convex body it bendeth again the ſame way. By which means the whole action of the Sun-beams are encloſed within a very ſmall compaſs; in which place therefore there muſt be a very vehement Motion; and conſequently if there be in that place combuſtible matter, ſuch as is not very hard kindle, the parts of it will be diſſipated, and receive that Motion which worketh on the Eye as other Fire does.

The ſame reaſon is to be given for burning by Reflection. For there alſo the Beams are collected into almoſt a point.

A. *Why may not the Sun-beams be ſuch a Body as we call Fire, and paſs through the pores of the glaſs ſo diſpoſed as to cary them to a point, or very near?*

B. Can there be a glaſs that is all pores; If there cannot, then cannot this effect be produced by the paſſing of Fire through the pores. You have ſeen men

light their Tobacco at the Sun with a burning glaſs, or with a ball of Criſtal, held which way they will indifferently. Which muſt be impoſſible, unleſs the ball were all pores. Again, neither you nor I can conceive any other Fire then we have ſeen, nor then ſuch as water will put out. But not only a ſolid Globe of Glaſs or Criſtal will ſerve for a burning Glaſs, but alſo a hollow one filled with water. How then does the Fire from the Sun paſs through the glaſs of water without being put out before it come to the matter they would have it burn?

A. *I know not. There comes nothing from the Sun. If there did, there is come ſo much from it already, that at this day we had had no Sun,*

CHAP.

CHAP. V.

Problems of Hard and Soft.

A. *WHat call you Hard, and what Soft.*

B. That body whereof no one part is eaſily put out of its place, without removing the whole, is that which I and all men call Hard; and the contrary Soft. So that they, are but degrees one of another.

A. *What is the cauſe that makes one body Harder then another, or (ſeeing you ſay they are but degrees of one another) what makes one body Softer then another, and the ſame body ſometimes Harder, ſometimes Softer?*

B. The ſame Motion which we have ſuppoſed from the beginning for the cauſe of ſo many other effects. Which Motion not being upon the center of the part moved, but the part it ſelf going in another circle to and again, it is not neceſſary that the Motion be perfectly circular. For it is not circulation, but the reciprocation, I mean the to and again that does caſt off, and lacerrate the Air, and conſequently produce the fore-mentioned effects.

For the cauſe therefore of Hardneſs, I ſuppoſe the reciprocation of Motion in thoſe things which are Hard, to be very ſwift, and in very ſmall circles.

A. *This is ſomewhat hard to believe. I would you could ſupply it with ſome viſible experience.*

B. When you ſee (for example) a Croſs-bow bent, do you think the parts of it ſtir?

A. *No. I am ſure they do not.*

B. How are you ſure? You have no argument for it, but that you do not ſee the Motion. When I ſee you ſitting ſtill, muſt I believe there is no Motion in your parts within, when there are ſo many arguments to convince me there is.

A. *What argument have you to convince me that there is Motion in a Croſs-bow when it ſtands bent?*

B. If you cut the ſtring, or any way ſet the Bow at liberty it will have then a very viſible Motion. What can be the cauſe of that?

A. *Why the ſetting of the Bow at liberty.*

B. If the Bow had been crooked before it was bent, and a ſtring tied to both ends, and then cut aſunder, the Bow would not have ſtir'd. Where lies the difference?

A. *The Bow bent has a Spring; unbent it has none, how crooked ſoever.* *P.*

B. What mean you by Spring?

A. *An endeavour of reſtitution to it's former poſture.*

B. I underſtand Spring as well as I do endeavour.

A. *I mean a Prnciple or beginning of Motion in a contrary way to that of the force which bent it.*

B. But the beginning of Motion is alſo Motion, how inſenſible ſoever it be. And you know that nothing can give a beginning of Motion to it ſelf. What is it therefore that gives the Bow (which you ſay you are ſure was at reſt when it ſtood bent) its firſt endeavour to return to its former poſture?

A. *It was he that bent it.*

B. That cannot be. For he gave it an endeavour to come forward, and the Bow endeavours to go backward.

A. *Well, grant that endeavour be Motion, and Motion in the Bow unbent, how do you derive from thence, that being ſet at liberty it muſt return to its former poſture?*

B. Thus There being within the Bow a ſwift (though inviſible) Motion of all the parts, and conſequently of the whole; the bending cauſeth that Motion, which was along the Bow (that was beaten out when it was hot into that length) to o-

perate a croſs the length in every part of it, and the more by how much it is more bent; and conſequently endeavours to unbend it all the while it ſtands bent. And therefore when the force which kept it bent is removed, it muſt of neceſſity return to the poſture it had before.

A. *But has that endeavour no effect at all before the impediment be removed? For if endeavour be Motion, and every Motion have ſome effect more or leſs, methinks this endavour ſhould in time produce ſomething.*

B. So it does. For in time (in a long time) the courſe of this internal Motion will lie along the Bow, not according to the former, but to the new acquired poſture. And then it will be as uneaſie to return it to its former poſture, as it was before to bend it.

A. *That's true. For Bows long bent loſe their appetite to reſtitution, long cuſtom becoming nature. But from this internal reciprocation of the parts, how do you infer the Hardneſs of the whole Body.*

B. If you apply force to any ſingle part of ſuch a body, you muſt needs diſorder the Motion of the next parts to it before it yield, and there diſordered, the Motion of the next again muſt alſo be diſordered; and conſequently no one part can yield with-

without force ſufficient to diſorder all. But then the whole body muſt alſo yield. Now when a body is of ſuch a nature as no ſingle part can be removed without removing the whole, men ſay that body is Hard.

A. *Why does the Fire melt divers Hard bodies, and yet not all?*

B. The hardeſt bodies are thoſe wherein the Motion of the parts are the moſt ſwift, and yet in the leaſt circles.

Wherefore if the Fire, the Motion of whoſe parts are ſwift, and in greater circiles, he made ſo ſwit, as to be ſtrong enough to maſter the Motion of the parts of the Hard body, it will make thoſe parts to move in a greater compaſs, and thereby weaken their reſiſtance, that is to ſay, Soften them, which is a degree of liquefaction. And when the Moton is ſo weakened, as that the parts loſe their coherence by the force of their own weight, then we count the body melted.

A. *Why are the Hardeſt things the moſt brittle, inſomuch that what force ſoever is enough to bend them, is enough alſo to break them?*

B. In bending a Hard body, as (for example) a Rod of Iron, you do not inlarge the ſpace of the internal Motion of the parts of Iron, as the Fire does;

but you master and interrupt the Motion, and that chiefly in one place. In which place the Motion that makes the Iron Hard being once overcome, the prosecution of that bending must needs suddenly master the Motions of the parts next unto it, being almost mastered before.

A. *I have seen a small piece of glass, the figure whereof is this* A A B C. *Which piece of glass if you bend toward the top, as in* C, *the whole body will shatter asunder into a Million of pieces, and be like to so much dust. I would fain see you giv e a probable reason of that.*

B. I have seen the Experiment. The making of the glass, is thus, They dip an Iron Rod into the molten glass that stands in a Vessel within the Furnace. Upon which Iron Rod taken out, there will hang a drop of molten but tough Mettal of the figure you have described, which they let fall into the water. So that the main drop comes first to the water, and after it the tail, which though streight whilst it hung on the end of the Rod, yet by falling into the water becomes crooked. Now you know the making of it, you may consider what must be the consequence of it. Because the main drop A comes first to the water, it is therefore first quenched, and consequently that the Motion

tion of the parts of that drop, which by the Fire were made to be moved in a larger compaſs, is by the water made to ſhrink into leſſer circles towards the other end B, but with the ſame or not much leſs ſwiftneſs.

A. *Why ſo?*

B. If you take any long piece of Iron, Glaſs, or other uniform and continued body; and having Heated one end thereof, you hold the other end in your hand, and ſo quench it ſuddenly, though before, you held it eaſily enough, yet now it will burn your fingers.

A. *It will ſo.*

B. You ſee then how the Motion of the parts from A toward C is made more violent and in leſs compaſs by quenching the other parts firſt. Beſides, the whole Motion that was in all the parts of the main drop A, is now united in the ſmall end B C. And this I take to be the cauſe why that ſmall part B C is ſo exceeding ſtiff. Seeing alſo this Motion in every ſmall part of the glaſs, is not only circular, but proceeds alſo all along the glaſs from A to B, the whole Motion compounded will be ſuch as the Motion of Spinning any Soft matter unto Thread, and will diſpoſe the whole body of the glaſs in Threads, which in other Hard bodies are called the grain. There-

Therefore if you bend this body (for example) in C (which to do will require more force then a man would think that has not tryed) thoſe threads of Glaſs muſt needs be all bent at the ſame time, and ſtand ſo, till by the breaking of the Glaſs at C, they be all at once ſet at liberty. And then all at once being ſuddenly unbent, like ſo many brittle, and over-bent Bows, their Strings breaking, be ſhivered in pieces.

A. *'Tis like enough to be ſo. And if nature have betrayed her ſelf in any thing, I think it is in this, and in that other experience of the Croſs-bow; which ſtrongly and evidently demonſtrates the internal reciprocation of the Motion, which you ſuppoſe to be in the internal parts of every Hard body. And I have obſerved ſomewhat in Looking-glaſſes which much confirms that there is ſome ſuch Motion in the internal parts of Glaſs, as you have ſuppoſed for the cauſe of Hardneſs. For let the Glaſs be* A B, *and let the Object at* C *be a Candle, and the Eye at* D. *Now by divers Reflections and Refractions in the two ſuperficies of the Glaſs, if the Lines of Viſion be very oblique, you ſhall ſee many images of the Candle, as* E, F, G, *in ſuch order and poſition as is here deſcribed. But if you remove your Eye to* C, *and the Candle to* D,

they

they will appear in a ſituation manifeſtly different from this. Which you will yet more plainly perceive if the Looking-Glaſs be coloured, as I have obſerved in Red and Blew Glaſſes; and could never conceive any probable cauſe of it, till now you tell me of this ſecret Motion of the parts acroſs the grain of the Glaſs, acquired by cooling it this or that way.

B. There be very many kinds of Hard bodies, Metals, Stones, and other kinds in the bowels of the Earth, that have been there ever ſence the beginning of the World; and I believe alſo many different ſorts of Juices that may be made Hard. But for one general cauſe of Hardneſs it can be no other then ſuch an internal Motion of parts as I have already deſcribed, whatſoever may be the cauſe of the ſeveral concomitant qualities of their Hardneſs in particular.

A. *We ſee water Hardened every Froſty day. It's likely therefore you may give a pribable cauſe of Ice. What is the cauſe of Freezing of the Ocean towards the Poles of the Earth?*

B. You know the Sun being always between the Tropicks, and (as we have ſuppoſed) always caſting off the Air; and the Earth likewiſe caſting it off from it's ſelf, there muſt needs on both

ſides

ſides be a great Stream of Air towards the Poles, ſhaving the ſuperficies of the Earth and Sea, in the Northern and Southern Climates. This ſhaving of the Earth and Sea by the Stream of Air muſt needs contract and make to ſhrink thoſe little Circles of the internal parts of Earth and Water, and conſequently Harden them, firſt at the ſuperficies, into a thin skin, which is the firſt Ice; and afterwards the ſame Motion continuing, and the firſt Ice co-operating, the Ice becomes thicker. And this I conceive to be the cauſe of the Freezing of the Ocean.

A. *If that be the cauſe, I need not ask how a Bottle of water is made to Freeze in warm weather with Snow, or Ice mingled with Salt. For when the Bottle is in the midſt of it, the Wind that goeth out both of the Salt and of the Ice as they diſſolve, muſt needs ſhave the ſuperficies of the Bottle, and the Bottle work accordingly on the water without it, and ſo give it firſt a thin skin, and at laſt thicken it into a ſolid piece of Ice. But how comes it to paſs that water does not uſe to Freeze in a deep Pit?*

B. A deep Pit is a very thick Bottle, and ſuch as the Air cannot come at but only at the top, or where the Earth is very looſe and ſpungy.

A. *Why will not Wine Freeze as well as Water?*

B. So it will when the Froſt is great enough. But the internal Motion of the parts of Wine and other Heating Liquors is in greater Circles and ſtronger then the Motion of the parts of water; and therefore leſs eaſily to be Frozen, eſpecally quite through, becauſe thoſe parts that have the ſtrongeſt Motion retire to the center of the Veſſel.

CHAP. VI.

Problems of Rain, Wind, *and other* WEATHER.

A. *WHat is the original cauſe of* Rain? *and how is it generated?*

B. The motion of the Air (ſuch as I have deſcribed to you already) tending to the diſ-union of the parts of the Air, muſt needs cauſe a continual endeavour (there being no poſſibility of *Vacuum*) of whatſoever fluid parts there are upon the face of the Earth and Sea, to ſupply the place which would elſe be empty.

This makes the water, and alſo very ſmall and looſe parts of the Earth and Sea to

to riſe, and mingle themſelves with the Air, and to become miſt and Clouds. Of which the greateſt quantity ariſe there, where there is moſt water, namely, from the large parts of the Ocean; which are the South Sea, the *Indian* Sea, and the Sea that divideth *Europe* and *Africa* from *America*; over which the Sun, for the greateſt part of the year is perpendicular, and conſequently raiſeth a greater quantity of water. Which afterwards gathered into Clouds, falls down in Rain.

A. *If the Sun can thus draw up the water; though but in ſmall drops, why can it not as eaſily hold it up?*

B. It is likely it would alſo hold them up, if they did not grow greater by meeting together, nor were carried away by the Air towards the Poles.

A. *What makes them gather together?*

B. It is not improbable that they are carried againſt Hills, and there ſtopt till more overtake them. And when they are carried towards the North or South where the force of the Sun is more oblique and thereby weaker, they deſcend gently by their own weight. And becauſe they tend all to the center of the Earth, they muſt needs be united in their way for want of room, and ſo grow bigger. And then it Rains.

A.

A. *What is the reaſon it Rains ſo ſeldom, but Snows ſo often upon very high Mountains?*

B. Becauſe perhaps when the water is drawn up higher then the higheſt Mountains, where the courſe of the Air betwcen the Æquator and the Poles is free from ſtopping, the Stream of the Air Freezeth it into Snow. And 'tis in thoſe places only where the Hills ſhelter it from that Stream, that it falls in Rain.

A. *Why is there ſo little Rain in* Egypt, *and yet ſo much in other parts nearer the Æquinoctial, as to make the Nile overflow the Countrey?*

B. The cauſe of the falling of Rain, I told you was the the ſtopping, and conſequently the collection of Clouds about great Mountains, eſpecially when the Sun is near the Æquinoctial, and thereby draws up the water more potently, and from greater Seas. If you conſider therefore that the Mountains in which are the ſprings of *Nile*, lye near the Æquinoctial and are exceeding great, and near the *Indian* Sea, you will not think it ſtrange there ſhould be great ſtore of Snow. This as it melts makes the Rain of *Nile* to riſe, which in *April* and *May* going on toward *Egypt* arrived there about the time of the Solſtice, and overflow the Countrey.

A.

A. *Why ſhould not the* Nile *then overflow that Countrey twice a year? For it comes twice a year to the Æquinoctial.*

B. From the *Autumnal Æquinox*, the Sun goeth on toward the Southern Tropique. And therefore cannot diſſolve the Snow on that ſide of the Hills that look towards *Egypt.*

A. *But then there ought to be ſuch another Innundation Southward.*

B. No doubt but there is a greater deſcent of water there in their Summer then at other times; as there muſt be whereſoever there is much Snow melted. But what ſhould that innundate, unleſs it ſhould overflow the Sea that comes cloſe to the foot of thoſe Mountains? And for the cauſe why it ſeldom Rains in *Egypt*, it may be this, That there are no very high Hills near it to collect the Clouds. The Mountains whence *Nile* riſeth being near 2000 Miles off. The neareſt on one ſide are the Mountains of *Nubia*, and on the other ſide *Sina*, and the Mountains of *Arrabia.*

A. *Whence think you proceed the Winds?*

B. From the Motion (I think) eſpecially of the Clouds, partly alſo from whatſoever is moved in the Air.

A. *It is manifeſt, that the Clouds are moved*

moved by the Winds; ſo that there were Winds before any clouds could be moved. Therefore I think you make the Effect before the Cauſe.

B. If nothing could move a Cloud but Wind, your objection were good. But you allow a Cloud to deſcend by it's own weight. But when it ſo deſcends, it muſt needs move the Air before it, even to the Earth, and the Earth again repel it, and ſo make lateral Winds every way. Which will carry forwards other Clouds if there be any in their way, but not the Cloud that made them The Vapour of the water riſing into Clouds, muſt needs alſo as they riſe, raiſe a Wind?

A. *I grant it. But how can the ſlow motion of a Cloud make ſo ſwift a Wind as it does?*

B. It is not one or two little Clouds, but many and great ones that do it. Beſides, when the Air is driven into places already covered; it cannot but be much the ſwifter for the narrowneſs of the paſſage.

A. *Why does the South Wind more often then any other bring Rain with it?*

B. Where the Sun hath moſt power, and where the Seas are greateſt, that is in the South, there is moſt water in the Air; which a South wind can only bring

to us. But I have ſeen great ſhowers of Rain ſometimes alſo when the wind hath been North, but it was in Summer, and came firſt, I think, from the South or Weſt, and was but brought back from the North.

A. *I have ſeen at Sea very great Waves when there was no Wind at all. What was it then that troubled the Water?*

B. But had you not Wind enough preſently after?

A. *We had a Storm within a little more then a quarter of an hour after.*

B. That Storm was then coming and had moved the Water before it. But the Wind you could not perceive, for it came downwards with the deſcending of the Clouds, and preſſing the Water bounded above your Sail till it came very near. And that was it that made you think there was no Wind at all.

A. *How comes it to paſs that a Ship ſhould go againſt the Wind which moves it, even almoſt point blank, as if it were not driven but drawn?*

B. You are to know firſt, that what Body ſoever is carryed againſt another Body, whether perpendicularly, or obliquely, it drives it in a perpendicular to the ſuperficies it lighteth on. As for Example, a Bullet ſhot againſt a flat wall, meketh

maketh the Stone (or other matter it hits) to retire in a perpendicular to that flat; or, if the Wall be round, towards the center, that is to ſay, perpendicularly. For if the way of the motion be oblique to the Wall, the motion is compounded of two motions, one parrallel to the Wall, and the other perpendicular. By the former whereof the Bullet is carried along the Wall ſide, by the other it approacheth to it. Now the former of theſe motions can have no effect upon it; all the battery is from the motion perpendicular, in which it approacheth. And therefore the part it hits muſt alſo retire perpendicularly. If it were not ſo, a Bullet with the ſame ſwiftneſs would execute as much obliquely ſhot, as perpendicularly; which you know it does not.

A. *How do you apply this to a Ship?*

B. Let *A. B.* be the Ship, the head of it *A.* If the Wind blow juſt from *A.* towards *B.* 'tis true, the Ship cannot go forward howſoever the ſail be ſet. Let *C. D.* be perpendicular to the Ship, and let the Sail *E. C.* be never ſo little oblique to it, and *F. C.* perpendicular to *E. C.* and then you ſee the Ship will gain the ſpace *D. F.* to the headward.

A. *It will ſo, but when it is very near*

to the Wind it will go forward very ſlowly; and make more way with her ſide to the Leeward.

A. It will indeed go ſlower in the proportion of the Line *A, E.* to the Line *C. E.* But the Ship will not go ſo faſt as you think ſideward: One is the force of that Wind which lights on the ſide of the Ship it ſelf; the other is, the bellying of the Sail; for the former, it is not much becauſe the Ship does not eaſily put from her the Water with her ſide; and bellying of the Sail, gives ſome little hold for the Wind to drive the Ship a ſtern.

A. *For the motion ſideward I agree with you; but I had thought the bellying of the Sail, had made the Ship go faſter.*

B. But it does not; only in a fore-wind it hinders leaſt.

A. *By this reaſon a broad thin Board ſhould make the beſt Sail.*

B. You may eaſily foreſee the great incommodities of ſuch a Sail. But I have ſeen tryed in little what ſuch a Wind can do in ſuch a caſe. For I have ſeen a Board ſet upon four truckles, with a ſtaff ſet up in the midſt of it for a Maſt, and another very thin and broad Board faſtned to that ſtaff in the ſtead of a Sail; and ſo ſet as to receive the Wind very obliquely, I mean ſo as to be within a point of the Com-

Compaſs directly oppoſite to it; and ſo placed upon a reaſonable ſmooth pavement where the Wind blew ſomewhat ſtrongly. The event was firſt, that it ſtood doubting whether it ſhould ſtir at all or no, but that was not long; and then it ran a head extream ſwiftly, till it was overthrown by a Rub.

A. *Before you leave the Ship tell me how it comes about that ſo ſmall a thing as a* Rudder, *can ſo eaſily turn the greateſt Ship* ?

B. 'Tis not the *Rudder* only, there muſt alſo be a ſtream to do it; you ſhall never turn a Ship with a *Rudder* in a ſtanding pooll, nor in a natural current.

You muſt make a ſtream from head to ſtern, either with Oares or with Sails: when you have made ſuch a ſtream, the turning of the *Rudder* obliquely holds the Water from paſſing freely; and the Ship or Boat cannot go on directly, but as the *Rudder* inclines to the ſtern, ſo will the Ship turn. But this is too well known to inſiſt upon: you have obſerved, that the Rudders of the greateſt Ships are not very broad, but go deep into the Water, whereas Weſtern Barges, though but ſmall Veſſels, have their Rudders much broader, which argues that the holding of Water from paſſing is the

office of a Rudder: and therefore to a Ship that draws much Water the Rudder is made deep accordingly, and in Barges that draw little Water, the Rudders as leſs deep, muſt ſo much the more be extended in breadth.

A. *What makes Snow?*

B. The ſame cauſe which (ſpeaking of Hardneſs) I ſuppoſed for the cauſe of Ice. For the Stream of Air proceeding from. That both the Earth and the Sun caſt off the Air, and conſequently maketh a ſtream of Air from the Æquinoctial towards the Poles, paſſing amongſt the Clouds, ſhaving thoſe ſmall drops of Water whereof the Clouds conſiſt, and congeals them as they do the Water of the Sea, or of a River. And theſe ſmall frozen drops are that which we call Snow.

A. *But then how are great drops frozen into Hailſtones, and that eſpecially (as we ſee they are) in Summer?*

B. It is eſpecially in Summer; and hot weather, that the drops of Water which make the Clouds, are great enough; but it is then alſo that Clouds are ſooner and more plentifully carryed up. And therefore the current of the Air ſtrengthned between the Earth and the Clouds, becomes more ſwift; and thereby freezeth the

the drops of Water, not in the Cloud it ſelf, but as they are falling. Nor does it freeze them throughly, the time of their falling not permitting it, but gives them only a thin coat of Ice; as is manifeſt by their ſuddain diſſolving.

A. *Why are not ſometimes alſo whole Clouds when pregnant and ready to drop, frozen into one piece of Ice?*

B. I belive they are ſo whenſoever it Thunders.

A. *But upon what ground do you believe it?*

B. From the manner or kind of noiſe they make, namely a crack; which I ſee not how it can poſſibly be made by Water or any other ſoft Bodies whatſoever.

A. *Yes, the Powder they call* Aurum Fulminans, *when throughly warm, gives juſt ſuch another crack as Thunder.*

B. But why may not every ſmall grain of that *Aurum Fulminans* by it ſelf be heard, though a heap of them together be ſoft, as is any heap of Sand. Salts of all ſorts are of the nature of Ice. But Gold is diſſolved into *Aurum Fulminans* by Nitre and other Salts. And the leaſt grain of it gives a little crack in the fire by it ſelf. And therefore when they are ſo warmed by degrees, the crack cannot chuſe but be very great.

A. *But before it be* Aurum Fulminans *they uſe to waſh away the Salt (which they call dulcifying it,) and then they dry it gently by degrees.*

B. That is, they exhale the pure Water that is left in the Powder, and leave the Salt behind to Harden with drying. Other Powder made of Salts without any Gold in them will give a crack as great as *Aurum Fulminans.* A very great Chymiſt of our times hath written, that *Salt* of *Tarter*, *Salt-peter*, and a little *Brimſtone* ground together into a Powder, and dryed, a few grains of that Powder will be made by the fire to give as great a Clap as a Muſquet.

A. *Me thinks it were worth your tryal to ſee what effect a Quart or a Pint of* Aurum Fulminans *would produce, being put into a great Gun made ſtrong enough on purpoſe, and the Breech of the Gun ſet in hot Cinders, ſo as to heat by degrees, till the Powder fly.*

B. I pray you try it your ſelf; I cannot ſpare ſo much Money.

A. *What is it that breaketh the Clouds when they are frozen?*

B. In very hot weather the Sun raiſeth from the Sea and all moiſt places abundance of Water, and to a great height. And whilſt this Water hangs over us in

Clouds,

Clouds, or is again deſcending, it raiſeth other Clouds, and it hapens very often that they preſs the Air between them, and ſqueeze it through the Clouds themſelves very violently; which as it paſſes ſhaves and hardens them in the manner declared.

A. *That has already been granted, my queſtion is what breaks them?*

B. I muſt here take in one ſuppoſition more.

A. *Then your Baſen (it ſeems) holds not all you have need of.*

B. It may for all this, for the ſuppoſition I add is no more but this; that what internal motion I aſcribe to the Earth, and other the Concrete parts of the World, is to be ſuppoſed alſo in every of their parts how ſmall ſoever; for what reaſon is there to think, in caſe the whole Earth have in truth the motion I have aſcribed to it, that one part of it taken away, the remaining part ſhould love that motion. If you break a Load-ſtone both parts will retain their vertue, though weakened according to the diminution of their quantity; I ſuppoſe therefore in every ſmall part of the Earth, the ſame kind of motion, which I have ſuppoſed in the whole: and ſo I recede not yet from my Baſen.

A.

A: *Let it be ſuppoſed, and withall, that abundance of Earth (which I ſee you aim at,) be drawn up together with the Water. What then?*

B. Then if many pregnant Clouds, ſome aſcending and ſome deſcending meet together, and make concavities between, and by the preſſing out of the Air, as I have ſaid before, become Ice; thoſe Atomes (as I may call them) of Earth will be by the ſtraining of the Air through the water of the Clouds, be left behind, and remain in the Cavities of the Clouds, and be more in number then for the proportion of the Air therein. Therefore for want of liberty they muſt needs juſtle one another, and become (as they are more and more ſtreightened of room) more and more ſwift, and conſequently at laſt break the Ice ſuddenly and violently, now in one place, and by and by in another; and make thereby ſo many claps of Thunder, and ſo many Flaſhes of Lightning. For the Air Recoiling upon our Eyes, is that which maketh thoſe Flaſhes to our Fancy.

A. *But I have ſeen Lightning in a very clear Evening, when there has been neither Thunder nor Clouds.*

B. Yes in a clear evening; becauſe the Clouds and the Rain were below the Horiſon,

Horiſon, perhaps 40 or 50 Miles off; ſo that you could not ſee the Clouds nor hear the Thunder.

A. *If the Clouds be indeed Frozen into Ice, I ſhall not wonder if they be ſometimes alſo ſo ſcituated, as (like Looking-Glaſſes) to make us ſee ſometimes three or more Suns by Refraction and Reflection.*

CHAP. VII.

Problems of Motion Perpendicular, Oblique; of Preſſion and Percuſſion; Reflection and Refraction; Attraction and Repulſion.

IF *a Bullet from a certain point given, be ſhot againſt a wall Perpendicularly and again from the ſame Point Oblique, What will be the proportion of the Forces wherewith they urge the wall?*

For Example, let the wall be A B, *a point given* E, *a Gun* C E *that carries the Bullet Perpendicularly to* F, *and another Gun* D E *that carries the like Bullet with the ſame ſwiftneſs Oblique to* G; *In what proportion will their Forces be upon the Wall?*

B. The force of the ſtroke Perpendicular from E to F will be greater then the

the Oblique force from E to G, in the proportion of the line E G to the line E F.

A. *How can the difference be ſo much? Can the Bullet loſe ſo much of its force in the way from* E *to* G *?*

B. No we will ſuppoſe it loſeth nothing of its ſwiftneſs. But the cauſe is, That their ſwiftneſs being equal, the one is longer in coming to the wall then the other, in Proportion of Time, as E G to E F. For though their ſwiftneſs be the ſame, conſidered in themſelves, yet the ſwiftneſs of their approach to the wall is greater in E F then in E G, in proportion of the lines themſelves.

A. *When a Bullet enters not, but rebounds from the wall, does it make the ſame Angle going off, which it did falling on, as the Sun-beams do?*

B. If you meaſure the Angles cloſe by the wall there difference will not be enſible; otherwiſe it will be great enough, For the Motion of the Bullet grows continually weaker. But it is not ſo with the Sun-beams which preſs continually and equally.

A. *What is the cauſe of Reflection? When a body can go no further on, it has loſt its Motion. Whence then comes the Motion by which it reboundeth?*

B.

B: This Motion of rebounding or reflecting proceedeth from the reſiſtance. There is a difference to be conſidered between the Reflection of Light, and of a Bullet, anſwerable to their different Motions, preſſing and ſtriking. For the action which makes Reflection of Light, is the Preſſure of the Air upon the Reflecting Body, cauſed by the Sun, or other ſhining body, and is but a contrary endeavour; as if two men ſhould preſs with their breaſts upon the two ends of a Staff, though they did not remove one another, yet they would find in themſelves a great diſpoſition to preſs backward upon whatſoever is behind them, though not a total going out of their places. Such is the way of Reflecting Light. Now, when the falling on of the Sun-beams is Oblique, the action of them is nevertheleſs Perpendicular to the Superficies it falls on. And therefore the Reflecting Body, by reſiſting, turneth back that Motion Perpendicularly, as from F to E, but taketh nothing from the force that goes on parallel in the line of E H; becauſe the Motion never preſſes. And thus of the two Motions from F to E, and from E to H is a compounded Motion in the line F H, which maketh an Angle in B G, equal to the Angle F G E. But

But in Percuſſion (which is the Motion of the Bullet againſt a wall,) the Bullet no ſooner goeth off then it loſeth of its ſwiftneſs, and inclineth to the Earth by its weight. So that the Angles made in falling on and going off, cannot be equal, unleſs they be meaſured cloſe to the point where the ſtroke is made.

A. *If a man ſet a Board upright upon its edge, though it may very eaſily be caſt down with a little Preſſure of ones finger, yet a Bullet from a Musquet ſhall not throw it down but go through it. What is the cauſe of that?*

B. In preſſing with your finger you ſpend time to throw it down. For the Motion you give to the part you touch is communicated to every other part before it fall. For the whole cannot fall till every part be moved. But the ſtroke of a Bullet is ſo ſwift, as it breaks through before the Motion of the part it hits can be communicated to all the other parts that muſt fall with it.

A. *The ſtroke of a Hammer will drive a Nail a great way into a piece of Wood on a ſudden. What weight laid upon the head of a Nail, and in how much time will do the ſame? It is a queſtion I have heard propounded amonſt Naturaliſts,*

B. The different manner of the ope-

ration

ration of weight from the operation of a ſtroke, makes it uncalculable. The ſuddenneſs of the ſtroke upon one point of the wood takes away the time of reſiſtance from the reſt. Therefore the Nail enters ſo far as it does. But the weight not only gives them time, but alſo augments the reſiſtance; but how much, and in how much time, is (I think) impoſſible to determine.

A. *What is the difference between Reflection and Recoiling?*

B. Any Reflection may (and not unproperly) be called recoiling; but not contrariwiſe every Recoiling Reflection. Reflection is always made by the Re-action of a Body preſt or ſtricken; but Recoiling not always. The Recoiling of a Gun is not cauſed by its own preſſing upon the Gun-powder, but by the force of the Powder it ſelf, inflamed and moved every way alike.

A. *I had thought it had been by the ſudden re-entring of the Air after the flame and Bullet were gone out. For it is impoſſible that ſo much room as is left empty by the diſcharging of the Gun, ſhould be ſo ſuddenly filled with the Air that entereth at the Touch-hole.*

B. The flame is nothing but the Powder it ſelf, which ſcattered into its ſmal-

leſt

leſt parts ſeems, of greater bulk by much, then in truth it is, becauſe they ſhine. And as the parts ſcatter more and more, ſo ſtill more Air gets between them, entring not only at the Touch-hole, but alſo at the mouh of the Gun. which two ways being oppoſite, it will be much too weak to make the Gun Recoil.

A. *I have heard that a great Gun charged too much or too little, will Shoot (not above, nor below but) beſides the mark; and charged with one certain charge between both will hit it.*

B. How that ſhould be I cannot imagine. For when all things in the cauſe are equal, the effects cannot be unnequal. As ſcon as Fire is given, and before the Bullet be out, the Gun begins to Recoil. If then there be any unevenneſs or rub in the ground more on one ſide then on the other, it ſhall ſhoot beſides the mark, whether too much, or too little, or juſtly charged; becauſe if the line wherein the Gun Recoileth decline, the way of the Bullet will alſo decline to the contrary ſide of the mark. Therefore I can imagine no cauſe of this event, but either in the ground it Recoils on, or in the unequal weight of the parts of the Breech.

A. *How comes Refraction?*

B. When the action is in a line Perpendicular

pendicular to the ſuperficies of the Body wrought upon, there will be no Refraction at all. The action will proceed ſtill in the ſame ſtraight Line, whether it be Preſſion as in Light, or in Percuſſion as in the ſhooting of a Bullet. But when the Preſſion is Oblique, then will the Refraction be that way which the Nature of the Bodies through which the Action proceeds ſhall determin.

H. *How is light Refracted?*

B. If it paſs through a Body of leſs, into a Body of greater reſiſtance, and to the Point of the Superficies it falleth on, you draw a Line Perpendicular to the ſame ſuperficies, the Action will proceed not in the ſame Line by which it fell on, but in another Line bending toward that Perpendiculare.

A. *What is the reaſon of that?*

B. I told you before, that the falling on worketh only in the Perpendicular; But as ſoon as the Action proceedeth further inward then a meer touch, it worketh partly in the Perpendicular, and partly forward, and would proceed in the ſame line in which it fell on, but for for the greater reſiſtance which now weakneth the Motion forward, and makes it to incline towards the Perpendicular.

A. *In tranſparent Bodies it may be ſo; but there be Bodies through which the Light cannot paſs at all.*

B. But the Action by which Light is made, paſſeth through all Bodies. For this Action is Preſſion; and whatſoever is preſt, preſſeth that which is next behind, and ſo continually. But the cauſe why there is no Light ſeen through it, is the unevenes of the parts within, whereby the Action is by an infinite number of Reflections ſo diverted and weakned, that before it hath proceeded through, it hath not ſtrength left to work upon the Eye ſtrongly enough to produce ſight.

A. *If the Body being tranſparent the Action proceed quite through, into a Body again of leſs reſiſtance, as out of Glaſs into the Air, which way ſhall it then proceed in the Air?*

B. From the Point where it goeth forth, draw a Perpendicular to the ſuperficies of the Glaſs, the Action now freed from the reſiſtance it ſuffered, will go from that Perpendicular, as much as it did before come towards it.

A. *When a Bullet from out of the Air entreth into a Wall of Earth, will that alſo be Refracted towards the Perpendicular?*

B.

B. If the Earth be all of one kind, it will. For the parallel Motion, will there alſo at the firſt entrance be reſiſted, which it was not before it entred.

A. *How then comes a Bullet, when ſhot very Obliquely into any broad Water, and having entred, yet to riſe, again into the Air?*

B. When a Bullet is ſhot very Obliquely, though the Motion be never ſo ſwift, yet approach downwards to the Water is very ſlow, and when it cometh to it, it caſteth up much Water before it, which with its weight preſſeth downwards again, and maketh the Water to riſe under the Bullet with force enough to maſter the weak Motion of the Bullet downwards, and to make it riſe in ſuch manner as Bodies uſe to riſe by Reflection.

A. *By what Motion (ſeeing you aſcribe all Effects to Motion) can a* Load-ſtone *draw* Iron *to it?*

B. By the ſame Motion hitherto ſuppoſed. But though all the ſmalleſt parts of the Earth have this Motion, yet it is not ſuppoſed that their Motions are in equal Circles; nor that they keep juſt time with one another; nor that they have all the ſame Poles. If they had, all Bodies would draw one another

alike. For ſuch an agreement of Motion, of Way, of Swiftneſs, of Poles, cannot be maintained without the conjunction of the Bodies themſelves in the Center of their common Motion, but by violence.

If therefore the *Iron* have but ſo much of the Nature of the *Load-ſtone* as redily to receive from it the like Motion, as one String of a *Lute* doth from another String ſtrained to the ſame Note (as it is like enough it hath, the *Load-ſtone* being but one kind of *Iron* Ore) it muſt needs after that Motion received from it, (unleſs the greatneſs of the weight hinder) come nearer to it, becauſe at diſtance their Motions will differ in time, and oppoſe each other whereby they will be forced to a common Center. If the *Iron* be lifted up from the Earth, the Motion of the *Load-ſtone* muſt be ſtronger, or the Body of it nearer, to overcome the Weight; and then the *Iron* will leap up to the *Load-ſtone* as as Swiftly as from the ſame diſtance, it would fall down to the Earth; but if both the *Stone* and the *Iron* be ſet floating upon the Water, the attraction will begin to be manifeſt at a greater diſtance, becauſe the hindrance of the weight is in part removed.

A.

A. *But why does the* Load-ſtone *if it float on a Calm Water, never fail to place it ſelf at laſt in the Meridian juſt* North *and* South.

B. Not ſo, juſt in the Meridian, but almoſt in all places with ſome variations. But the cauſe I think is, that the Axis of this Magnetical Motion is parallel to the Axis of the Ecliptique, which is the Axis of the like Motion in the Earth, and conſequently that it cannot freely exerciſe its Natural Motion in any other Scituation.

A. *Whence may this conſent of Motion in the* Load-ſtone *and the Earth proceed? Do you think (as ſome have written) that the Earth is a great* Load-ſtone *?*

B. Dr. *Gilbert* that was the firſt that wrote any thing of this Subject rationally, inclines to that opinion. *Decartes* thought the Earth (excepting this upper cruſt of a few Miles depth) to be of the ſame Nature with all other Stars, and bright. For my part I am content to be ignorant ; but I believe the *Load ſtone* hath given its virtue by a long habitude in the Mine, the Vein of it lying in the plain of ſome of the Meridians, or rather of ſome of the great Circles that paſs through the Poles of the Ecliptique, which are the ſame with the Poles of

the like Motion ſuppoſed in the Earth.

A. *If that be true, I need not ask why the filings of* Iron *laid on a* Load-ſtone *equally diſtant from its Poles will lie parallel to the Axis, but one each ſide incline to the Pole that is next it. Nor why by drawing a* Load-ſtone *all a long a Needle of* Iron, *the Needle will receive the ſame Poles. Nor why when the* Load-ſtone *and* Iron (*or two* Load-ſtones) *are put together floating upon Water, will fall one of them a Stern of the other, that their like parts may look the ſame way, and their unlike touch, in which Action they are commonly ſaid to Repel one another. For all this may be deriv'd from the union of their Motions. One thing more I deſire to know, and that is; What are thoſe things they call* Spirits? *I mean* Ghoſts, Fairies, Hobgoblins, *and the like Apparitions.*

B. They are no part of the Subject of Natural Philoſophy.

A. *That which in all Ages, and all places is commonly ſeen (as thoſe have been, unleſs a great part of Mankind by Lyers) cannot, I think, be ſupernatural.*

B. All this that I have hitherto ſaid, though upon better ground than can be had for a diſcourſe of *Ghoſts*, you ought to take but for a Dream.

A.

A. *I do ſo. But there be ſome Dreams more like ſenſe then others. And that which is like ſenſe pleaſes me as well (in natural Philoſophy) as if it were the very truth.*

B. I was Dreaming alſo once of theſe things; but was weakened by their noiſe. And they never came into any Dream of mine ſince, unleſs Apparitionrs in Dreams and Ghoaſts be a ll one.

CHAP. VIII.

The Delphique Problem or Duplication of the Cube.

A. *HAve you ſeen a Printed Paper ſent from* Paris, *containing the Duplication of the* Cube, *written in* French?

B. Yes. It was I that Writ it, and ſent it thither to be Printed, on purpoſe to ſee what objections would be made to it by our Profeſſors of *Algebra* here.

A. *Then you have alſo ſeen the confutations of it by* Algebra.

B. I have ſeen ſome of them; and have one by me. For there was but one that was rightly Calculated, and that is it which I have kept.

A. *Your Demonſtration then is confuted though but by one.*

B. That does not follow. For though an Arithmetical Calculation be true in Numbers, yet the ſame may be, or rather muſt be falſe, if the Units be not conſtantly the ſame:

A. *Is their Calculation ſo inconſtant, or rather ſo fooliſh as you make it?*

B. Yes. For the ſame number is ſometimes ſo many Lines, ſometimes ſo many Plains, and ſometimes ſo many Solids; as you ſhall plainly ſee, if you will take the pains to examine firſt a Demonſtration I have to prove the ſaid Duplication, and after that, the *Algebrique* Calculation which is pretended to confute it. And not only that this one is falſe, but alſo any other Arithmetical account uſed in Geometry, unleſs the numbers be always ſo many Lines, or always ſo many ſuperficies, or always many ſolids.

A. *Let me ſee the Geometrical Demonſtration.*

B. There it is: Read it.

To find a Cube double to a Cube given.

LEt the ſide of the Cube given be V D. Produce V D to A, till A D be double to D V. Then make the

the ſquare of A D, namely A B C D. Divide A B and C D in the middle at E and F. Draw E F. Draw alſo A C cutting E F in I. Then in the ſides B C and A D take B R and A S each of them equal to A I or I C.

Laſtly, divide S D in the middle at T, and upon the Center T, with the diſtance T V, deſcribe a ſemi-circle cuting A D in Y, and D C in X.

I ſay the Cube of D X is double to the Cube of D V. For the three lines D Y, D X, D V are in continual proportion. And Cntinuing the ſemi-circle V X Y till it cut the line R S drawn and produced in Z, the line S Z, will be equal to D X. And drawing X Z it will paſs through T. And the four lines T V, T X, T Y and T Z will be equal. And therefore joyning Y X and Y Z, the Figure V X Y Z will be a Rectangle.

Produce C D to P ſo as D P be equal to A D. Now if Y Z produced fall on P, there will be three Rectangle equiangled Triangles, D P Y, D Y X, and D X V; and conſequently four continual proportionals, D P, D Y, D X, and D V, whereof D X is the leaſt of the means. And therefore the Cube of D X will be double to the Cube of D V.

A.

A. *That's true; and the Cube of* D Y *will be double to the Cube of* D X; *and the Cube of* D P *double to the Cube of* D Y. *But that* Y Z *produced, falls upon* P, *is the thing they deny, and which you ought to demonſtrate.*

B. If Y Z produced fall not on P, then draw P Y, and from V let fall a perpendicular upon P Y, ſuppoſe at *u*. Divide P V in the midſt at *a*, and joyn *a u*; which done *a u* will be equal to *a* V or *a* P. For becauſe V *u* P is a right Angle, the point *u* will be in the ſemi-circle whereof P V is the Diameter.

Therefore drawing V R, the Angle *u* V R will be a right Angle.

A. *Why ſo?*

B. Becauſe T V and T Y are equal; and T D, T S equal; S V will alſo be equal to D V. And becauſe D P and R S are equal and parallel, R Y will be equal and parallel to P V. And therefore V R and P Y that joyn them will be equal and parallel. And the Angles P *u* V, R V *u* will be alternate, and conſequently equal. But P *u* V is a right Angle; therefore alſo R V *u* will be a right Angle.

A. *Hitherto all is evident. Proceed.*

B. From the point Y raiſe a perpendicular

dicular cutting V R whereſoever in *t*, and then (becauſe P Y and V R are parallel) the Angle Y *t* V will be a right Angle. And the figure *u* Y *t* V a Rectangle, and *u t* equal to Y V. But Y V is equal to Z X; and therefore Z X is equal to *u t*. And *u t* muſt paſs through the point T (For the Diameters of any Rectangle, divide each other in the middle) therefore Z and *u* are the ſame point, and X and *t* the ſame point. Therefore Y Z produced falls upon P. And D X is the leſſer of the two means between A D and D V. And the Cube of D X double to the Cube of D V which was to be demoſtraten.

A *I cannot imagine what fault there can be in this Demonſtration, and yet there is one thing which ſeems a little ſtrange to me. And 'tis this. You take* B R, *which is half the Diagonal, and which is the ſine of* 45 *degrees, and which is alſo the mean proportional between the two Extreams. And yet you bring none of theſe proprieties into your Demonſtration. So that though you argue from the Conſtruction, yet you do not argue from the Cauſe. And this perhaps your adverſaries will object (at leaſt) againſt the Art of your Demonſtratieon, or*

enquire

enqure by what luck you pitched upon half the Diagonal for your Foundation.

B. I ſee you let nothing paſs. But for anſwer you muſt know, That if a man argue from the negative of the truth, though he know not that it is the truth which is denyed, yet he will fall at laſt, after many conſequences, into one abſurdity or another. For though falſe do often produce Truth, yet it produces alſo abſurdity, as it hath done here. But Truth produceth nothing but Truth. Therefore in Demonſtrations that tend to abſurdity, it is no good Logick to require all along the operation of the cauſe.

A. *Have you drawn from hence no Corollaries?*

B. No. I leave that for others that will; unleſs you take this for a Corollary, That, what Arithmetical Calculation ſoever contradicts it, is falſe.

A. *Let me ſee now the* Algebrical *Demonſtration againſt it.*

B. Here it is.

Let A B or A D be equal to — 2
Then D F or D V is equal to -- 1
And B R or A S is equal to } — 2
the ſquare root of ——— }
And A V equal to ——— 3
want the ſquare root of 2.
The Cube of A B is equal to -- 8

The

The Cube of D Y is equal to---45
want the Square Root of 1682
that is almoſt equal to——4
For 45 want the Square Root of 6681 is equal to —— } 4
Therefore D Y is a little leſs then the greater of the two Means between AD and DV.

A. *There is I ſee ſome little difference between this* Arithmetical *and your* Geometrical *Demonſtration. And though it be inſenſible, yet if his Calculation be true, yours muſt needs be falſe, which I am ſure cannot be.*

B. His Calculation is ſo true, that there is never a Propoſition in it falſe, till he come to the concluſion, that the Cube of D Y. is equal to 45, want the ſquare Root of 1682. But that, and the reſt, is falſe.

A. *I ſhall eaſily ſee that* A D. *is certainly* 2, *whereof* D V. *is* 1, *and* A V. *is certainly* 3, *whereof* D V. *is* 1.

B. Right.

A. *And* B R. *is without doubt the ſquare Root of* 2.

B. Why, what is 2 ?

A. 2, *is the Line* A D. *as being double to* D V. *which is* 1.

B. And ſo, the Line B R. is the ſquare Root of the Line A D.

A.

A. *Out upon it it, it's abſurd. Why do you grant it to be true in* Arithmetick?

B. In *Arithmetick* the numbers conſiſt of ſo many Units; and are never conſidered there as nothings. And therefore every one Line has ſome Latitude, and if you allow to B I. the Semi-diagonal the ſame Latitude you do to A B. or to B R. you will quickly ſee the Square of half the Diagonal to be equal to twice the Square of half A B.

A. *Well, but then your Demonſtration is not confuted; for the Point* Y, *will have Latitude enough to take in that little difference which is between the Root of* 1681 *and the Root of* 1682. *This putting off an Unit ſometimes for one Line, ſometimes for one Square, muſt needs marr the reckoning. Again he ſays the Cube of* A B. *is equal to* 8. *but ſeeing* A B. *is* 2, *the Cube of* A B. *muſt be juſt equal to four of its own ſides; ſo that the Unit which was before ſometimes a Line, ſometimes a Square, is now a Cube.*

B. It can be no otherwiſe when you ſo apply *Arithmetick* to *Geometry*, as to mumber the Lines of a Plain, or the Plains of a Cube.

A. *In the next place, I find that the Cube of* D Y. *is equal to* 45, *want the Square*

Square Root of 1622. *What is that* 45? *Lines, or Squares, or Cubes?*

B. Cubes, Cubes of DV.

A. *Then if you add to* 45 *Cubes of* DV. *the Square Root of* 1682, *the ſum will be* 45 *Cubes of* DV. *And if you add to the Cube of* DY. *the ſame Root of* 1682, *the ſum will be the Cube of* DY. plus *the Square Root of* 1682. *And theſe two ſums muſt be equal.*

B. They muſt ſo.

A. *But the Square Root of* 1682, *being a Line, adds nothing to a Cube; therefore the Cube alone of* DY. *which he ſays is equal almoſt to* 4. *Cubes of* DV. *is equal to* 45 *Cubes of the ſame* DV.

B. All theſe impoſſibilities do neceſſarily follow the confounding of *Arithmetick* and *Geometry.*

A. *I pray you let me ſee the Operation by which the Cube of* DY. (*that is the Cube of* 3, *want the Root of* 2,) *is found equal to* 45, *want the Square Root of* 1682.

A detection of the absurd use of *Arithmetick* as it is now applyed to *Geometry*.

B. Here it is.

3——r. 2.
3——r. 2.

——r. 18 + 2.
9—r. 18

9—r. 72 + 2.
3—r. 2.

——r. 162 + 12—r. 8.
27—r. 648 + 6

27---r. 658---r. 162 + 18---r. 8.

A. *Why for two Roots of* 18 *do you put the Root of* 72.

B. Because 2 Roots of 18 is equal to one Root of 4 times 18, which is 72.

A. *Next we have, That the Root of* 2 *Multiplyed into* 2, *makes the Root of* 8. *How is that true?*

B. Does it not make 2 Roots of 2? And is not B R. the Root of 2, and 2 B R equal to the Diagonal? And is not the

the diagonal the root of a ſquare equal to 8 ſquares of D V?

A. *'Tis true. But here the root of* 8 *is put for the Cube of the root of* 2. *Can a line be equal to a Cube?*

B. No. But here we are in Arithmetick again, and 8 is a Cubique number.

A. *How does the root of* 2 *multiplyed into the root of* 72 *make* 12?

B. Becauſe it makes the root of 2 times 72, that is to ſay the root of 144 which is 12.

A. *How does* 9 *roots of* 2 *make the root of* 162?

B. Becauſe it makes the root of 2 ſquares of 9, that is the root of 162.

A. *How does* 3 *roots of* 72 *make the root of* 648?

B. Becauſe it makes the root of 9 times 72, that is of 648.

A. *For the total Sum I ſee* 27 *and* 18 *which make* 45. *Therefore the root of* 648 *together with the root of* 162 *and of* 8, *which are to be deducted from* 45, *ought to be equal to the root of* 1682.

B. So they are. For 648 multiplyed by 162 makes 104976 of which the double root is ——————— 648 and 648 and 162 added together make ——————————— 810.

Therefore the root of 948, added to the root of 162 makes the root of -- 1458

Again 1458 into 8 is 11664. The double root whereof is ---------- 216.

The Sum of 1458 and 8 added together is ---------- 1466.

The Sum of 1466 and 216 is 1682, and the root, the root of ---------- 1682.

A. *I see the the Calculation in numbers is right, though false in lines. The reason whereof can be no other then some difference between multiplying numbers into lines or plains, and multiplying lines into the same lines or plains.*

B. The difference is manifest. For when you multiply a number into lines, the product is lines; as the number 2 multiplyed into 3 lines is no more then 3 lines 2 times told. But if you multiply lines into lines you make plains, and if you multiply lines into plains you make solid bodies. In Geometry there are but three dimensions, Length, Superficies, and Body. In Arithmetick there is but one, and that is Number or Length which you will. And though there be some Numbers called Plain, others Solid, others *Plano-solid*, others Square, others Cubique, others Square-square, others *Quadrato-cubique*, others Cubi-cubique *&c.* yet are all these but one dimension, namely Number

ber, or a file of things Numbered.

A. *But ſeeing this way of Calculation by Numbers is ſo apparently falſe, what is the reaſon this Calculation came ſo near the truth.*

B. It is becauſe in *Arithmetick* Units are not Nothings, and therefore have breadth. And therefore many Lines ſet together make a ſuperficies though their breadth be inſenſible. And the greater the number is into which you divide your Line, the leſs ſenſible will be your errour.

A. Archimedes, *to find a ſtreight Line equal to the circumferrence of a Circle, uſed this way of extracting Roots. And 'tis the way alſo by which the Table of* Sines, Secants *and* Tangents *have been calculated, Are they all Cut?*

B. As for *Archimedes*, there is no man that does more admire him then I do. But there is no man that cannot Err: His reaſoning is good. But he ads all other Geometricans before and after him, have had two Principles that croſs one another when they are applyed to one and the ſame Science. One is, that a Point is no part of a Line which is true in Geometry, where a part of a Line when it is called a Point, is not reckoned; another is, that a Unit is part of a

Number which is alſo true; but when they reckon by *Arethmetick* in *Geometry*, there a Unit is ſomtimes part of a Line, ſometimes a part of a Square, and ſometimes part of a Cube.

As for the Table of *Sines*, *Secants* and *Tangents*, I am not the firſt that find fault with them. Yet I deny not but they are true enough for the reckoning of Acres in a Map of Land.

A. *What a deal of Labour has been loſt by them that being Profeſſors of* Geometry *have read nothing elſe to their Auditors but ſuch ſtuff as this you have here ſeen. And ſome of them have written great Books of it in ſtrange characters, ſuch as in troubleſome times, a man would ſuſpect to be a Cypher.*

B. I think you have ſeen enough to ſatisfie you, that what I have written heretofore concerning the Quadrature of the Circle, and of other Figures made in imitation of the Parabola, has not been yet confuted.

A. *I ſee you have wreſted out of the hands of our Antagoniſts this weapon of Algebra, ſo as they can never make uſe of it again. Which I conſider as a thing of much more conſequence to the ſcience of* Geometry, *then either of the Duplication of the Cube, or the finding of two mean Proportionals, or the Quadrature of a Circle, or all theſe Problems put together.*

FINIS.

Books Written by this Author, and Printed for *William Crooke*.

1 *DE Mirabilibus Pecci*, in Quarto Latin, in Octavo in Engliſh and Lantin.
2 Three Papers to the *Royal Society* againſt Dr. *Wallis*.
3 *Lumathematica*.
4 Prima partis Doctrinæ *Walliſianæ* de *Motu Cenſura Brevis*.
5 *Reſetum Geometricum*, ſive propoſitiones aliquot fruſtra antehac tentatæ.
6 *Principia* & *Poblemata* aliquot *Geometrica*, ante deſperata, nunc breviter explicata & demonſtrata.
7 *Quadratura Circuli Cubatio Sphæræ* duplicatio Cubi Breviter demonſtrata.
8 *Conſideration* on his *Loyalty*, *Reputation*, *Religion* and *Manners*; by himſelf.
9 *De Principio* & *Ratione Geometri*:
20 The *Travels* of *Uliſes Tranſlated* from *Homer*.
11 *Epiſtol.* ad Dr. *Wood*.
12 The *Tranſlation* of all *Homers Works* into *Engliſh*.
13 The *Epitome* of the *Civil Wars* of *England* from 1640 to 1660.
14 *Ariſtotles Rhetorick Tranſlated* into *Engliſh* by him, with his own *Rhetorick* to it.

15 *A Dialogue betwixt a Student* in the *Common-Laws* of *England*, and a *Philosopher* in which is set forth the *Errors* in some Practise.

16 *A Narration* of *Heresie* and the *Punishment* thereof.

17 *Ten Dialogues* of *Natural Philosophy*.

18 *A Poem* in *Latin* of his *Life*.

19 ——idem the same in *English*.

20 *His Life* written in Latin, part by himself and the rest by Dr. *R. B.* wherein is contained the most material parts of his Life.

21 *Seven Philosophical Problems*, and two *Propositions* of *Geometry*. With an *Apology* for Himself, and his *Writings*. Dedicated to the King, in the year 1662.